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## Information System Development To Recognize The Status Of Complex Systems Based On Rendering Engines And The Methods Of Fuzzy Sets Theory.

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### ABSTRACT

The development algorithm description for multi-dimensional virtual image of the patient's condition is performed. This condition is used to solve the problem of his illness nosological form recognition based on a study of the relative position topology and the intersection collision of two-dimensional condition images by the k-fold projection of the developed multi-dimensional image on the plane coincident with the screen plane of a multi-color monitor using the fuzzy sets. We consider the developed structure of the system being developed, the data streams, allowing obtain the insight into the health information system are described, the domain model using a functional approach is designed.

**Keywords:** Diagnosis, algorithm, geometric method of pattern recognition, fuzzy sets, visualization, projection, multi-dimensional virtual image.

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## INTRODUCTION

It is known that computer diagnostics is closely related to the information accumulation and processing, so the representation methods and information analysis quality in the future are necessary for the correct diagnosis of a disease and the effective patient treatment [1]. During the operation with the information diagnostics is based on the acquisition of data on the the current patient status and the interpretation of such data, which is based on the currently available methods of clinical data investigation [2,3].

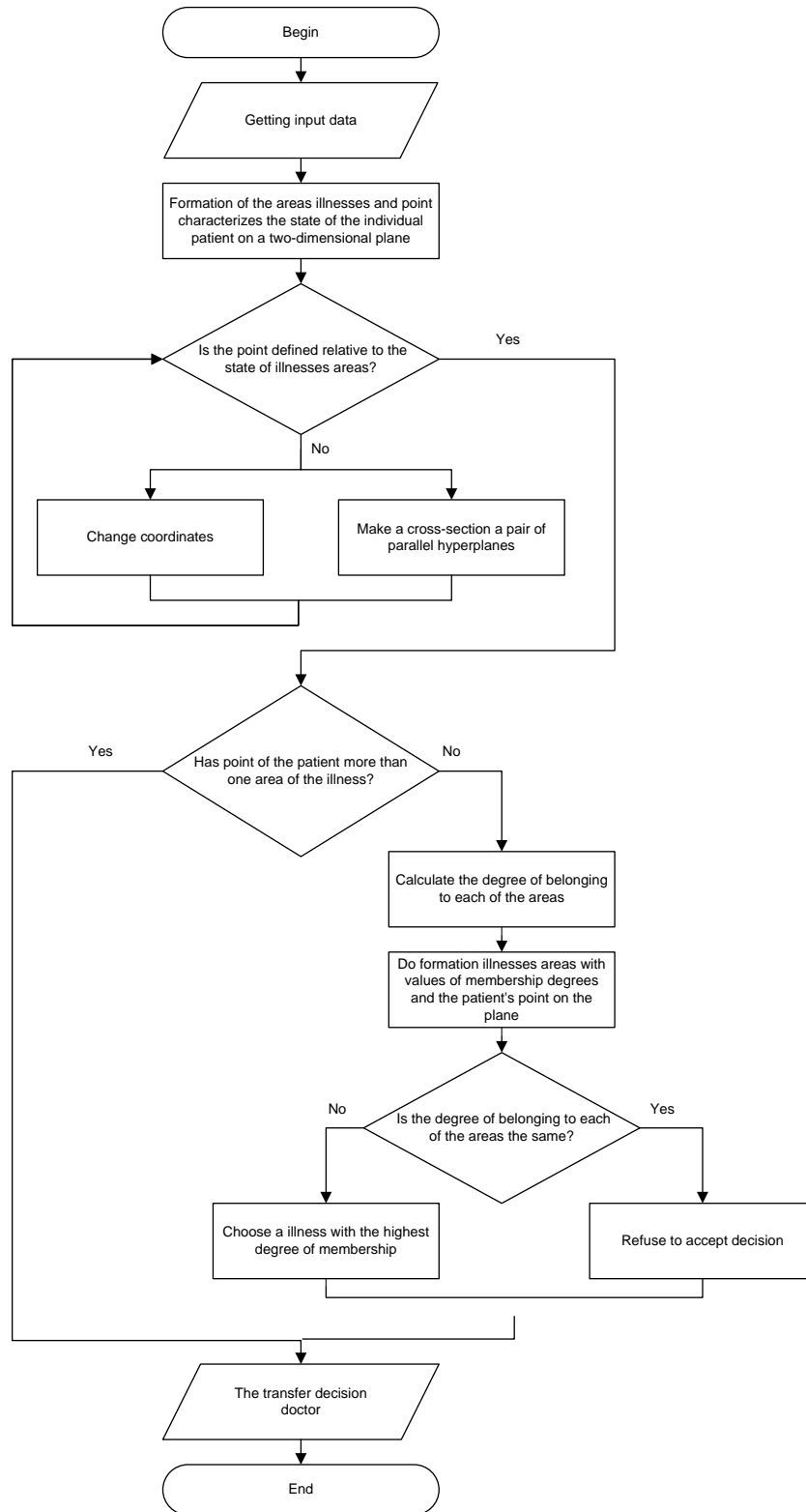
Obviously, the solution of the heart condition visualization problem will prevent gross errors in medical practice, increase the effectiveness of cardiac information treatment, and make a diagnosis and a visual representation of the current state of cardiovascular system (CVS) perception comfortable.

In accordance with the developed concept of CVS status monitoring the mathematical model of the heart shall allow cardiologists to get a clear picture of the patient state as a whole. In At that the imaging procedure should serve as a tool for the analysis and diagnostics.

### Main part

The solution of the diagnostics (recognition) problem concerning the complex objects status [4] is based on the analysis and interpretation of the available data on the current patient status and his medical history. The algorithm to solve the problem of computer diagnostics (see Fig. 1) based on the geometric method of pattern recognition and fuzzy sets theory application is being considered. It is assumed that the developed algorithm performs the following basic procedures needed to solve the mentioned problem:

- The formation of virtual volume models with different clinical nosological forms of the disease in N-dimensional feature space -  $B_i$  in the form of M loci, where M is the number of cases;  $i = 1; 2; 3 \dots$  and multidimensional virtual image that characterizes a particular patient state.
- The development of the patient state two-dimensional image ( $A_2(t)$ ) and  $B_{2i}$  dimensional images representing the  $A_N(t)$  and  $B_i$  projections on the plane coinciding with the plane of the multicolor monitor screen.
- The analysis of the mutual arrangement topology  $A_2(t)$  relative to  $B_{2i}$  and also the mutual arrangement of  $B_{2i}$  relative to each other. According to the results of the performed analysis the algorithm includes the following procedures:
  - ✓ Generation of a medical decision concerning a relevant disease presence when the suppression fact  $A_2(t)_{iS}$  determined with only one of  $B_{2i}$ ;
  - ✓ The problem solution of a strict medical decision about the relevant disease presence when the fact of belonging ( $A_2(t)$ ) simultaneously to two or more  $B_{2i}$  is established. At that during the first stage, the problem of  $B_{2i}$  conflict is solved by the coordinates transfer, achieving the situation where there is only one intersection of  $A_2(t)$  with a single  $B_{2i}$  among several ones. Then a medical decision on the presence of the particular disease is generated. If the considered approach does not lead to the solution of a  $B_i$  crossing issue conflict, then the approach based on the theory of fuzzy sets is used to generate a clear medical decision for a relevant disease.



**Figure 1: Patient state diagnostics (algorithm scheme)**

Let's start with the procedure of a patient condition two-dimensional image ( $A_2(t)$ ) and two-dimensional images  $B_2i$  development representing the projection of  $A_N(t)$  and  $B_i$  on the  $\{X', Y'\}$  plane (see Fig. 2), which coincides with the displaying multicolor monitor screen plane.

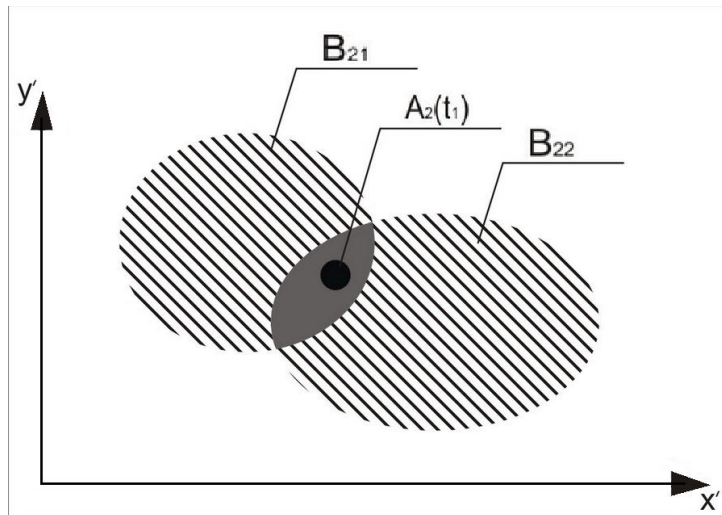


Figure 2: Plane mutual location topology  $\{ X', Y' \}$ , coinciding with the plane of the multicolored monitor screen, two-dimensional image of the states and two-dimensional virtual models of disease nosological forms.

However, during the practical implementation of the method described in [5,6], there are situations that contribute to the ambiguity of a management decision on the current patient state. Such situations may occur due to the fact that the hyper volume disease areas  $B_i$  within the N-dimensional state space may be identical according to a variety of clinical data, which in its turn causes a complete  $B_{2i}$  match or a partial overlap with each other. In these cases, the instantaneous value of  $A_2(t)$  may be located at the intersection of two or more  $B_{2i}$  (see Fig. 3a). Two possible approaches are proposed in [5,6] so as to avoid the ambiguity at the solution of the patient recognition problem ( $A_2(t)$ ).

The first approach involves the implementation of the relevant k-shifts of the coordinates origin for a N-dimensional state space in the points on the plane selected by expert on a multicolor screen where  $k = 1; 2; 3; \dots j$ , thus forming a sufficient set of ( $A_2^k(t)$ ) and the plurality of two-dimensional models of different clinical forms of the disease ( $B_{2i}^k$ ). The  $A_2^k(t)$  and  $B_{2i}^k$  sufficiency is judged by the fact of  $A_2^k(t)$  belonging to one of only, or upon  $A_2(t) \notin B_{2i}$  condition performance (Figure 3b.). However, in practice the procedure of coordinate origin transfer does not always allow a satisfactory solution of the patient condition unambiguous recognition problem.

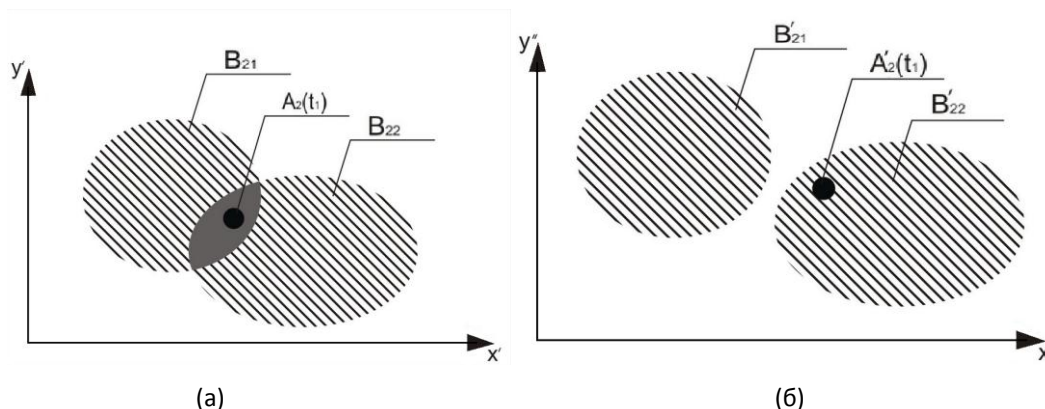
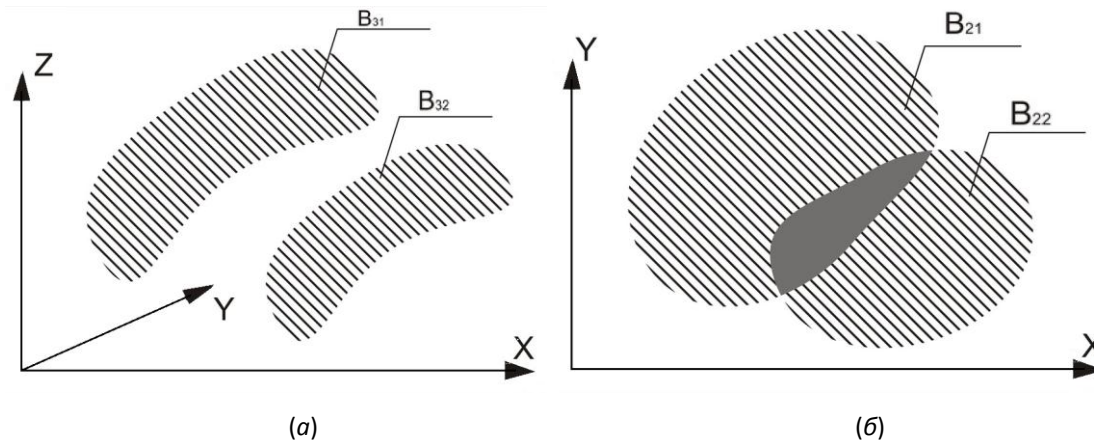


Figure 3: Relative position on the plane  $\{ X', Y' \}$  topology, which coincides with the plane of a multi-color monitor screen, a two-dimensional state image and two-dimensional virtual models of nosological diseases, corresponding to the point of time  $t_1$ : (a) - after the k-th transition of N-dimensional state space  $A_2^k(t_1)$ ,  $B_{21}^k$ , and  $B_{22}^k$ , respectively; (b) - after the k + 1-th transition of N-dimensional state space coordinate origin -  $A_2^{k+1}(t_1)$ ,  $B_{21}^{k+1}$  and  $B_{22}^{k+1}$ , respectively.

The second approach is implemented also if B<sub>2i</sub> diseases foci are located closely and have an extended shape (see Fig. 4a) in which the distance from the center of one disease area to some points of the neighboring disease area is less than the distance to its own points [7]. Consequently, the data of disease area are linearly separable in the n-dimensional space and are overlapped partially (see Fig. 4b).



**Figure 4: The topology of two virtual models position of nosologic disease forms which are closely spaced extended regions in a three-dimensional space (a) and their projections on the plane {X,Y} of a multicolor monitor screen (b).**

The proposed approach consists in the dissection of extended disease region set with a pair of hyperplanes perpendicular to the direction vector of one dissecting class among other ones.

If you are unable to determine a  $B_{2i}^k$  disease area of  $A_2^k(t)$  point after the first and second approach performance, it is concluded that these disease areas are overlapped. In this regard, we consider this situation as an opportunity to reduce the degree of recognition ambiguity  $A_{2B_1B_2}(t)$  by applying the theory of fuzzy sets [8,9,10,11,12], which allows to quantify the value of belonging index for the current value of a two-dimensional image of the object state to the corresponding image of  $B_{21}$  in the field of its actual crossing with each other. This approach provides for a specific set of procedures. At that the classes of diagnoses and a virtual image of an object state (a set of attributes) are considered in a multidimensional feature space -  $B_i$  and  $A_{NB_iB_j}(t)$  where  $A_{NB_iB_j}(t)$  is the  $A_N(t)$  value, located at the intersection of two or more  $B_i$ . The functions of belonging are determined during the first stage for each term of linguistic variables describing  $A_{NB_iB_j}(t)$ . In this regard, all the features are specified as linguistic variables. Then, the experts determine which of the linguistic variable term corresponds to a particular class of diagnoses  $B_1$ .

It should be noted that in case of ambiguity, i.e. when several classes of diagnoses have equal maximum degree of membership, the decision is not accepted and the rejection from the diagnostics in this case is declared.

Thus, one of the possible approaches to improve the method of object state recognition in the situation characterized by a partial intersection of  $B_{2i}$  with each other in a multidimensional feature space is considered. The problem solution is based on the combined use of projective geometric method of pattern recognition and the fuzzy set theory, which allows for a quantitative assessment of the state parameters current value  $G_q(A_2(t))$  to each of the state classes at the corresponding point belonging to the intersection region  $B_{2i}$ . The proposed solution may be considered as a new approach to support the decision making allowing the automation of monitoring, the operational control or the analysis of change patterns occurring in complex systems.

We use a functional approach for the design of domain models. The development of the IDEF0 diagram allows us to describe all necessary processes with the accuracy sufficient for a clear simulation. Let's define all incoming and outgoing documents, methods, and objects to develop a general model of information flows.

The input objects are the patient symptoms and his personal data. The output system objects are the reporting documents and presumptive diagnosis (control medical decision). IDEF0 diagram is shown by Figure 5.

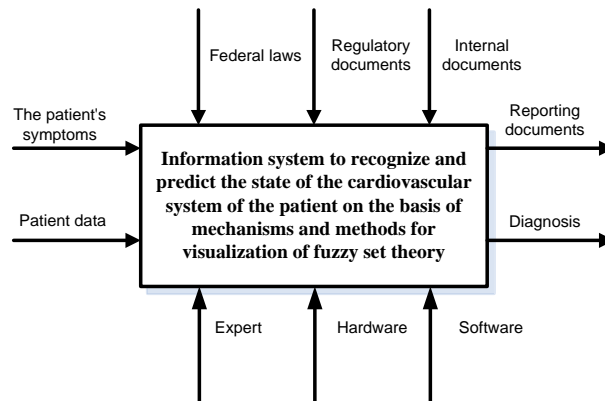


Figure 5: Functional model for state recognition and visualization tools of complex diagnostic systems

The result of the system operation is the graphical representation of a number of diseases on the screen plane and the definition of the patient disease by studying the behavior of his characteristic symptoms, relative to the presented diseases.

The activity is carried out by the employees who are qualified physicians and are the users of the system. Some of the functions are performed by the software, which is divided into the general (operating system, drivers, etc.) and specialized (developed information system, etc.)

Figure 6 shows the second block decomposition for the functional model "Fuzzy sets theory use".

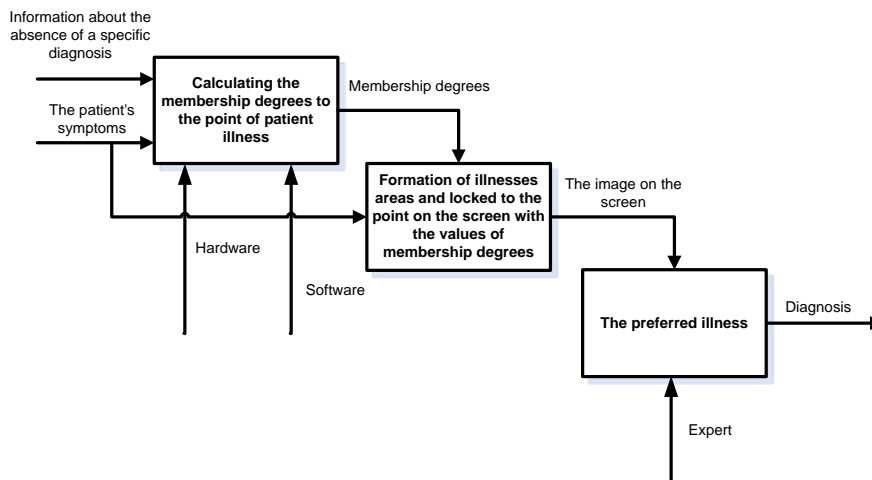


Figure 6: "Fuzzy sets theory use" decomposition block.

### CONCLUSION

The advantage of the proposed approach, the essence of which consist in the fact that diagnosis class intersection zones are defined initially in the multidimensional feature space by using the previously developed method of recognition, and then the fuzzy sets theory device is used only for those areas of intersections, which greatly reduces the time of experts survey and the load for each of them, and also many options for the diagnostics rejection are removed.

**SUMMARY**

The application of the clinical practice method will allow us to monitor and analyze the disease flow patterns and thus to improve the disease diagnosis accuracy and in some cases to solve the prediction problems.

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